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(54) **VISUAL PROSTHESIS INCLUDING ENHANCED RECEIVING AND STIMULATING PORTION**
SEHPROTHESE MIT VERBESSERTEM EMPFANGS- UND STIMULATIONSTEIL
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EP 1 487 538 B1

Description

FIELD OF THE INVENTION

[0001] This invention relates generally to a visual prosthesis for restoring at least partial vision to a user afflicted with photoreceptor degeneration.

BACKGROUND OF THE INVENTION

[0002] U.S. Patent 5,935,155 describes a visual prosthesis generally comprised of (1) an image acquiring and transmitting portion and (2) a receiving and retina stimulating portion. The acquiring portion includes a camera for generating a visual signal output representative of an acquired image. The stimulating portion includes an electrode array adapted to be operatively attached to the user's retina. The visual signal output is used to modulate a radio frequency (RF) carrier signal which is applied to a primary coil. A secondary coil receives the RF signal which is then demodulated to recover the visual signal output for driving the electrode array to electrically stimulate retinal tissue. In use, the acquiring and transmitting portion is mounted outside of the eye (extraocular) and the receiving and stimulating portion is primarily mounted in the eye (intraocular). The components of the intraocular portion are powered from energy extracted from the transmitted visual signal.

[0003] Figure 1 of Patent 5,935,155 comprises a functional block diagram of the visual prosthesis showing its image acquiring and transmitting portion and its receiving and retina stimulating portion. Figures 2 and 3 respectively show the organization of functional components of the respective portions of Figure 1. Figures 4, 5, and 6 depict alternative arrangements for deploying the prosthesis physical components. In all of the figures, the primary coil is mounted in alignment with the optic axis in front of the eye, e.g., in an eyeglass lens, frame, or in a soft contact lens. In Figure 4, the secondary coil is implanted behind the iris and a circuit housing is collocated therewith. In Figure 5, the secondary coil is implanted behind the iris but the circuit housing is located outside of the sclera wall.

[0004] In Figure 6, the secondary coil is placed adjacent the outer sclera surface. Patents 5,800,530 and 6,120,538 describe alternative visual prostheses.

[0005] US 5935155 proposes a visual prosthesis comprising a camera for perceiving a visual image and generating a visual output, retinal tissue stimulation circuitry adapted to be operatively attached to the user's retina and wireless communication circuitry for transmitting the visual signal output to the retinal tissue stimulation circuitry within the eye.

SUMMARY OF THE INVENTION

[0006] According to the present invention, there is provided a prosthesis for at least partially restoring vision to

a user suffering from a photoreceptor degenerative condition as set out in claim 1.

[0007] In accordance with a first preferred embodiment of the invention, the secondary coil is placed within the vitreous body of the user's eye positioned and oriented for good signal coupling to the extraocular primary coil. For example, both coils are located in close proximity substantially coincident with the optic axis of the user's eye. Moreover, the secondary coil is arranged to be in good thermal contact with the vitreous body which acts as a heat sink.

[0008] In accordance with a significant aspect of the first preferred embodiment, a signal processing circuitry electrically connected to the secondary coil is also placed in the vitreous body to assure efficient heat transfer therefrom. The circuitry is preferably contained in a protective hermetically sealed housing which preferably comprises a metal can but which also can constitute any coating or envelope for protecting the circuitry from adverse effects of salt water. The circuitry responds to an output signal from the secondary coil to produce an apparent image signal for driving an electrode array. The electrode array is configured to electrically stimulate the eye's retinal tissue to enable a user to perceive an apparent image.

[0009] In accordance with a further feature of the preferred embodiment, the housing, which is preferably metal, is placed and/or oriented in a manner to minimize the generation of eddy currents in the housing wall which would diminish energy transmission efficiency. In one arrangement, the housing is located posteriorly of the secondary coil but oriented with its shortest dimensions perpendicular to the secondary coil axis. In an alternative arrangement, the housing is displaced from the secondary coil axis but in substantially the same plane as the secondary coil.

[0010] In a still further embodiment the invention, the housing is placed outside the sclera wall and electrically connected through the sclera to the secondary coil and retina electrode array.

[0011] In accordance with a prosthesis example not forming part of the invention, the primary coil and secondary coil are both located to the side of the optic axis outside of the sclera wall enabling them to be closely coupled. The circuit housing is preferably located very close to the secondary coil and is electrically connected through the sclera to the retina electrode array.

BRIEF DESCRIPTION OF THE FIGURES

[0012]

Figure 1 is a functional block diagram of the visual prosthesis described in US Patent 5935155 showing its (1) image acquiring and transmitting portion and its (2) receiving and retina stimulating portion; Figures 2 and 3 are functional block diagrams respectively showing the organization of the (1) image acquiring and transmitting portion and the (2) receiv-

ing and retina stimulating portion.

Figure 4 depicts a simplified cross-section of an eye showing the placement of receiving and stimulating components in accordance with a first embodiment of the present invention;

Figure 5 depicts a simplified cross-section of an eye showing the placement of receiving and stimulating components in accordance with a second embodiment of the present invention;

Figure 6 depicts a simplified cross-section of an eye showing the placement of receiving and stimulating components in accordance with a third embodiment of the present invention; and

Figure 7 depicts a simplified cross-section of an eye showing the placement of receiving and stimulating components in accordance with an example not forming part of the invention.

DETAILED DESCRIPTION

[0013] Figure 1 depicts the visual prosthesis 10 of US Patent 5935155 which includes an image capturing element, such as a standard charge coupled device (CCD) camera 12, whose output is processed and encoded in circuit block 14. This processed and encoded captured real image signal is then coupled via primary coil 16 to a secondary coil 18. For example, the real image signal can be transmitted as a modulated radio frequency (RF) carrier signal. The secondary coil 18 receives the real image signal and applies an output signal to the signal processing circuit block 20. This circuit block 20 decodes and demultiplexes the applied signal and then communicates an apparent image signal to an electrode array 22 which stimulates the retinal cells to produce phosphenes in a pattern to simulate vision.

[0014] It should be noted that the dashed line 24 in FIG. 1 is included to functionally separate the image acquiring and transmitting portion 26 from the image receiving and stimulating portion 28 of the visual prosthesis 10. The dashed line 24 may or may not indicate the physical separation of extraocular and intraocular components as will be described more fully hereinafter with reference to FIGS. 4-6.

[0015] The image acquiring and transmitting portion 26 of the visual prosthesis 10 is illustrated in greater detail in FIG. 2 which shows the output of camera 12 coupled to an image sampler circuit 30 whose output is passed to a pixel encoder 32. The output of encoder 32 is passed to a signal modulator 34 which modulates a radio frequency carrier signal generated by the carrier generator 36. This RF signal is then applied to the primary coil 16.

[0016] The encoding scheme is preferably optimized for the target image resolution which is primarily determined by the size of the implanted electrode array.

The encoded information typically includes such parameters as the magnitude, timing, and sequence of the stimulation pulses which will be generated by the electrode array to simulate the image through retinal stimulation.

[0017] The RF signal applied to primary coil 16 is received by the secondary coil 18 of the stimulating portion 28 as illustrated in greater detail in FIG. 3. The secondary coil 18 output is passed to the demodulator 38 where the RF carrier signal is removed and the encoded image signal recovered. The encoded image signal is then passed to a decoder/demultiplexer 40 which in turn outputs the image information to a current generator 42 which drives the individual electrodes of the electrode array 22. The electric power for components of the image receiving and stimulating portion 28 is derived from the energy contained in the coupled RF signal through rectifier 44.

[0018] Attention is now directed to Figure 4 which depicts a first embodiment of the invention in which all of the components of the receiving and retina stimulating portion 28 are implanted in the vitreous chamber 50 of a user's eye 51. The chamber 50 is filled with the vitreous body 52 which comprises a clear colorless transparent jelly. As depicted in Figure 4, the secondary coil 18 is fixed, e.g., by suture 53 to the adjacent sclera wall 54, just behind the lens 56. The secondary coil 18 is preferably axially aligned with the extraocular primary coil 16 and the optic axis of the eye. The respective coils are preferably mounted so that their planes are oriented substantially parallel to one another to achieve good signal coupling. The secondary coil 18 is physically and electrically connected 58 to signal processing circuitry 20 mounted in housing 60 which preferably comprises a metal can but which can constitute any coating or envelope capable of providing protection from the deleterious effects of salt water. The circuitry 20 in housing 60 is connected via conductor 62 to a flexible electrode array 22 physically and electrically contacting the user's retina 64.

[0019] It is significant to note that the secondary coil 18, housing 60 and electrode array 22 are all mounted in the vitreous body 52 in good thermal contact therewith. Thus, the vitreous body acts as a heat sink to cool the coil and electronic circuitry enabling the system to more efficiently utilize the signal energy derived from primary coil 16.

[0020] The housing 60 preferably comprises a hermetically sealed metal container having perpendicular width, depth, and length dimensions. In order to minimize eddy current induction into the housing wall, it is preferable to orient the housing with its smallest dimensions oriented parallel to the plane of coil 18 and preferably displaced from the coil axis.

[0021] Attention is now directed to Figure 5 which differs from Figure 4 in that housing 60 is placed to the side of coil 18 where it is fixed to the adjacent sclera wall, rather than hanging in the vitreous body as shown in Figure 4. The arrangement of Figure 5 offers greater mechanical stability and robustness than is available in Figure 4.

[0022] Figure 6 depicts a further embodiment in which the housing 60 is affixed to the extraocular side of the adjacent sclera wall. This housing placement has the ad-

vantage that essentially no eddy currents will be induced in the housing wall. Although housing placement is somewhat simplified relative to Figures 4 and 5, it nevertheless requires that conductive leads from the secondary coil and to the electrode array be passed through the sclera wall.

[0023] Figure 7 depicts an example not forming part of the invention which the housing 60 is mounted off-axis adjacent to the extraocular side of the adjacent sclera wall with the secondary coil 18 being wound around the housing. This collocation of housing and secondary coil offers the potential for miniaturization. Moreover, the off-axis placement of the secondary coil 18 enables the primary coil 16 to be mounted off-axis and in alignment as shown in Figure 7. This off-axis placement may permit the coils 16, 18 to be placed closer together to increase signal coupling therebetween and the efficiency of the wireless transmission. As in Figure 6, the arrangement of Figure 7 requires that conductive leads pass through the sclera wall for connection to the electrode array 22.

[0024] From the foregoing, it should now be appreciated that several enhanced prosthesis embodiments have been described characterized by the first feature and by one or more of the subsequent features:

- 1 - secondary coil mounted within the vitreous body;
- 2 - circuitry housing mounted within the vitreous body;
- 3 - circuitry housing collocated outside of the sclera wall displaced from the optic axis.

[0025] Although only a limited number of embodiments have been specifically described, it is recognized that various modifications and alternatives will occur to those skilled in the art which fall within the scope defined by the appended claims.

Claims

1. A prosthesis for at least partially restoring vision to a user suffering from a photoreceptor degenerative condition, said prosthesis including:

a stimulating portion (28) for electrically stimulating the user's retina to present an apparent image to the user,
said stimulating portion (28) including:

- a secondary coil (18) for responding to a coupled input signal to produce an output signal;
- an electrode array (22) separate from said secondary coil (18), but electrically coupled to said secondary coil (18), and configured for implantation in said user's eye; and
- signal processing circuitry (20) responsive to said output signal for applying an image

signal to said electrode array (22) for stimulating retinal cells in said user's eye,

characterised in that:

the secondary coil (18) is configured for mounting in the vitreous body (52) of the user's eye and is larger in circumference than the lens capsule.

2. The prosthesis of claim 1, wherein the signal processing circuitry (20) responsive to said output signal is contained in a protective hermetically sealed housing (60) configured for mounting in the vitreous body (52) of the user's eye.
3. The prosthesis of claim 2, wherein the housing (60) defines first and second perpendicularly oriented dimensions and wherein the housing (60) is oriented with the lesser of said dimensions extending substantially perpendicular to the axis of the secondary coil (18).
4. The prosthesis of claim 1, wherein the secondary coil (18) is configured for mounting in the vitreous body (52) with the axis of the secondary coil (18) extending substantially coincident with the optic axis of the user's eye.
5. The prosthesis of claim 4, wherein said secondary coil (18) is configured for mounting in the vitreous body (52) proximate to the temporal side of the sclera.
6. The prosthesis of claim 1, further including:

an image acquiring portion (26) including a primary coil (16) for producing a real image signal representative of a real image, wherein the secondary coil (18) is arranged to couple to the primary coil (16), so as to produce an output signal in response to said real image signal, and the signal processing circuitry (20) responsive to said output signal is contained in a protective hermetically sealed housing (60), the housing (60) being configured for mounting in the vitreous body (52) of the user's eye in good thermal contact therewith.
7. The prosthesis of claim 6, wherein the primary coil (16) and secondary coil (18) are configured for mounting in close proximity for coupling said real image signal from said image acquiring portion (26) to said stimulating portion (28).
8. The prosthesis of claim 7 wherein said primary and secondary coil (18) are configured to be supported substantially coincident with the optic axis of the user's eye.

er's eye.

9. The prosthesis of claim 6, wherein the housing (60) defines first and second perpendicularly oriented dimensions and wherein the housing (60) is oriented with the lesser of said dimensions extending substantially perpendicular to the axis of the secondary coil (18). 5
10. The prosthesis of claim 1, further including: 10
 - an image acquiring portion including an extraocular primary coil (16) for producing a real image signal representative of a real image, wherein the secondary coil (18) is arranged to couple to the primary coil (16), so as to produce an output signal in response to said real image signal, and the signal processing circuitry (20) responsive to said output signal is contained in a protective hermetically sealed housing (60), the housing (60) being configured for mounting adjacent to the extraocular side of the user's sclera wall. 15
11. The prosthesis of claim 10, further comprising conductive wires for electrically connecting said signal processing circuitry (20) through the user's scleral wall to said secondary coil (18) and said electrode array (22). 20
12. The prosthesis of claim 11 wherein the primary coil (16) and secondary coil (18) are configured to be mounted substantially in alignment with the optic axis of the user's eye. 25
13. The prosthesis of claim 11, wherein the primary coil (16) and secondary coil (18) are substantially aligned with one another along an axis displaced from the optic axis of the user's eye. 30

Patentansprüche

1. Prothese, um das Sehvermögen eines Trägers, der an einer Degeneration der Photorezeptoren leidet, zumindest teilweise wiederherzustellen, wobei die Prothese Folgendes umfasst: 35
 - einen Stimulationsabschnitt (28) zur elektrischen Stimulation der Netzhaut des Trägers, um dem Träger ein sichtbares Bild zu präsentieren, wobei der Stimulationsabschnitt (28) Folgendes umfasst: 40
 - eine Sekundärspule (18), die auf ein gekoppeltes Eingangssignal reagiert, um ein Ausgangssignal zu erzeugen; 45
 - eine Elektrodenanordnung (22), die von der Sekundärspule (18) getrennt vorliegt, aber 50

elektrisch mit dieser verbunden ist und ausgebildet ist, um in das Auge des Trägers implantiert zu werden; und
eine Signalverarbeitungsschaltung (20), die auf das Ausgangssignal responsiv ist, um ein Bildsignal an die Elektrodenanordnung (22) anzulegen, um Netzhautzellen im Auge des Trägers zu stimulieren,

dadurch gekennzeichnet, dass

die Sekundärspule (18) ausgebildet ist, um in dem Glaskörper (52) des Auges des Trägers angebracht zu werden und einen größeren Umfang aufweist als die Linsenkapsel.

2. Prothese nach Anspruch 1, worin die Signalverarbeitungsschaltung (20), die auf das Ausgangssignal responsiv ist, in einem hermetisch abgedichteten Schutzgehäuse (60) vorliegt, das ausgebildet ist, um in dem Glaskörper (52) des Auges des Trägers angebracht zu werden. 5
3. Prothese nach Anspruch 2, worin das Gehäuse (60) eine erste und eine zweite Dimension definiert, die im rechten Winkel aufeinander stehen, und worin das Gehäuse (60) so ausgerichtet ist, dass die kürzere Dimension sich im Wesentlichen im rechten Winkel auf die Achse der Sekundärspule (18) erstreckt. 10
4. Prothese nach Anspruch 1, worin die Sekundärspule (18) ausgebildet ist, um in dem Glaskörper (52) so angebracht zu werden, dass die Achse der Sekundärspule (18) im Wesentlichen mit der optischen Achse des Auges des Trägers übereinstimmt. 15
5. Prothese nach Anspruch 4, worin die Sekundärspule (18) ausgebildet ist, um in den Glaskörper (52) im Bereich der Schläfenseite in der Nähe der Lederhaut eingesetzt zu werden. 20
6. Prothese nach Anspruch 1, die ferner Folgendes umfasst: 25
 - einen Bilderfassungsabschnitt (26), der eine Primärspule (16) zur Erzeugung eines Realbildsignals umfasst, das ein Realbild repräsentiert, wobei 30
 - die Sekundärspule (18) so angeordnet ist, dass sie an die Primärspule (16) gekoppelt ist, um in Reaktion auf das Realbildsignal ein Ausgangssignal zu erzeugen, und 35
 - die Signalverarbeitungsschaltung (20), die auf das Ausgangssignal responsiv ist, in einem hermetisch abgedichteten Schutzgehäuse (60) aufgenommen ist, wobei das Gehäuse (60) ausgebildet ist, um in dem Glaskörper (52) des Auges des Trägers in gutem thermischem Kontakt 40

mit diesem angebracht zu werden.

7. Prothese nach Anspruch 6, worin die Primärspule (16) und die Sekundärspule (18) ausgebildet sind, um nahe aneinander angebracht zu werden, um eine Kopplung des Realbildsignals von dem Bilderfassungsabschnitt (26) zu dem Stimulationsabschnitt (28) zu ermöglichen. 5
8. Prothese nach Anspruch 7, worin die Primärspule und die Sekundärspule (18) ausgebildet sind, um im Wesentlichen mit der optischen Achse des Auges des Trägers übereinstimmend gelagert zu werden. 10
9. Prothese nach Anspruch 6, worin das Gehäuse (60) eine erste und eine zweite Dimension definiert, die im rechten Winkel aufeinander stehen, und worin das Gehäuse (60) so ausgerichtet ist, dass die kürzere Dimension im Wesentlichen im rechten Winkel auf die Achse der Sekundärspule (18) steht. 15 20
10. Prothese nach Anspruch 1, die ferner Folgendes umfasst:

einen Bilderfassungsabschnitt, der eine extraokulare Primärspule (16) zur Erzeugung eines Realbildsignals, das ein Realbild repräsentiert, umfasst, wobei 25

die Sekundärspule (18) so angeordnet ist, dass sie an die Primärspule (16) gekoppelt ist, um in Reaktion auf das Realbildsignal ein Ausgangssignal zu erzeugen, und 30

die Signalverarbeitungsschaltung (20), die auf das Ausgangssignal responsiv ist, in einem hermetisch abgedichteten Schutzgehäuse (60) aufgenommen ist, wobei das Gehäuse (60) ausgebildet ist, um benachbart zur extraokularen Seite der Sklerawand angebracht zu werden. 35
11. Prothese nach Anspruch 10, die ferner leitende Drähte umfasst, um die Signalverarbeitungsschaltung (20) durch die Lederhautwand des Trägers mit der Sekundärspule (18) und der Elektrodenanordnung (22) elektrisch zu verbinden. 40 45
12. Prothese nach Anspruch 11, worin die Primärspule (16) und die Sekundärspule (18) ausgebildet sind, um im Wesentlichen fluchtend mit der optischen Achse des Auges des Trägers angebracht zu werden. 50
13. Prothese nach Anspruch 11, worin die Primärspule (16) und die Sekundärspule (18) im Wesentlichen fluchtend entlang einer Achse ausgerichtet sind, die in Bezug auf die optische Achse des Auges des Trägers versetzt ist. 55

Revendications

1. Prothèse pour rétablir au moins partiellement la vision d'un utilisateur souffrant d'une condition dégénérative des photorécepteurs, ladite prothèse comprenant: 5

une portion de stimulation (28) pour stimuler électriquement la rétine de l'utilisateur afin de présenter une image apparente à l'utilisateur; ladite portion de stimulation (28) comprenant:

une bobine secondaire (18) pour répondre à un signal d'entrée couplé afin de produire un signal de sortie; un groupement d'électrodes (22) séparé de ladite bobine secondaire (18), mais couplé électriquement à ladite bobine secondaire (18), et configuré pour l'implantation dans l'oeil dudit utilisateur; et un circuit de traitement de signaux (20) réagissant audit signal de sortie pour appliquer un signal d'image audit groupement d'électrodes (22) pour stimuler les cellules de la rétine dans l'oeil dudit utilisateur,

caractérisée en ce que:

la bobine secondaire (18) est configurée pour être installée dans le corps vitreux (52) de l'oeil de l'utilisateur et a une plus grande circonférence que la capsule du cristallin.

2. Prothèse selon la revendication 1, dans laquelle le circuit de traitement de signaux (20) réagissant audit signal de sortie se trouve dans un boîtier de protection hermétiquement scellé (60) configuré pour l'installation dans le corps vitreux (52) de l'oeil de l'utilisateur.
3. Prothèse selon la revendication 2, dans laquelle le boîtier (60) définit des première et seconde dimensions orientées perpendiculairement, et où le boîtier (60) est orienté de façon que la plus petite parmi lesdites dimensions s'étende sensiblement perpendiculairement à l'axe de la bobine secondaire (18).
4. Prothèse selon la revendication 1, dans laquelle la bobine secondaire (18) est configurée pour l'installation dans le corps vitreux (52) de façon que l'axe de la bobine secondaire (18) s'étende d'une manière sensiblement coïncidente avec l'axe optique de l'oeil de l'utilisateur.
5. Prothèse selon la revendication 4, dans laquelle ladite bobine secondaire (18) est configurée pour l'installation dans le corps vitreux (52) à proximité du côté temporal de la sclère.

6. Prothèse selon la revendication 1, comprenant en outre:

une portion d'acquisition d'images (26) incluant une bobine primaire (16) pour produire un signal d'image réelle représentatif d'une image réelle, où la bobine secondaire (18) est agencée pour être couplée à la bobine primaire (16), de manière à produire un signal de sortie en réponse audit signal d'image réelle, et le circuit de traitement de signaux (20) réagissant audit signal de sortie se trouve dans un boîtier de protection hermétiquement scellé (60), le boîtier (60) étant configuré pour l'installation dans le corps vitreux (52) de l'oeil de l'utilisateur avec un bon contact thermique avec celui-ci.

7. Prothèse selon la revendication 6, dans laquelle la bobine primaire (16) et la bobine secondaire (18) sont configurées pour un montage en une proximité étroite pour le couplage dudit signal d'image réelle de ladite portion d'acquisition d'images (26) à ladite portion de stimulation (28).

8. Prothèse selon la revendication 7, dans laquelle lesdites bobines primaire et secondaire (18) sont configurées pour être supportées sensiblement d'une manière coïncidente avec l'axe optique de l'oeil de l'utilisateur.

9. Prothèse selon la revendication 6, dans laquelle le boîtier (60) définit des première et seconde dimensions orientées perpendiculairement, et où le boîtier (60) est orienté de façon que la plus petite desdites dimensions s'étende sensiblement perpendiculairement à l'axe de la bobine secondaire (18).

10. Prothèse selon la revendication 1, comprenant en outre:

une portion d'acquisition d'images incluant une bobine primaire extra-oculaire (16) pour produire un signal d'image réelle représentatif d'une image réelle, où la bobine secondaire (18) est agencée pour être couplée à la bobine primaire (16), de manière à produire un signal de sortie en réponse audit signal d'image réelle, et le circuit de traitement de signaux (20) réagissant audit signal de sortie se trouve dans un boîtier de protection hermétiquement scellé (60), le boîtier (60) étant configuré pour le montage d'une manière adjacente au côté extra-oculaire de la paroi de la sclère de l'utilisateur.

11. Prothèse selon la revendication 10, comprenant en

outre des fils conducteurs pour la connexion électrique dudit circuit de traitement de signaux (20) à travers la paroi de la sclère de l'utilisateur à ladite bobine secondaire (18) et audit groupement d'électrodes (22).

12. Prothèse selon la revendication 11, dans laquelle la bobine primaire (16) et la bobine secondaire (18) sont configurées pour être montées sensiblement en alignement avec l'axe optique de l'oeil de l'utilisateur.

13. Prothèse selon la revendication 11, dans laquelle la bobine primaire (16) et la bobine secondaire (18) sont sensiblement alignées l'une avec l'autre le long d'un axe déplacé de l'axe optique de l'oeil de l'utilisateur.

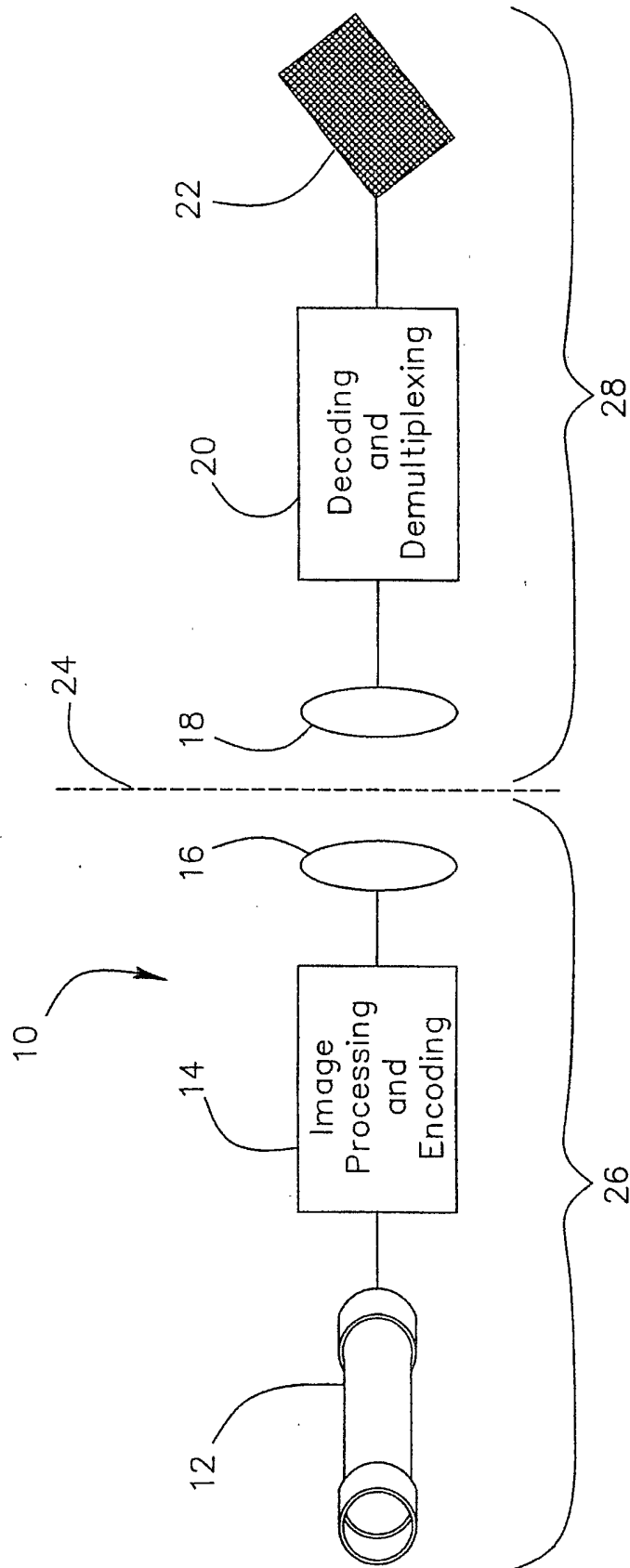


FIG. 1

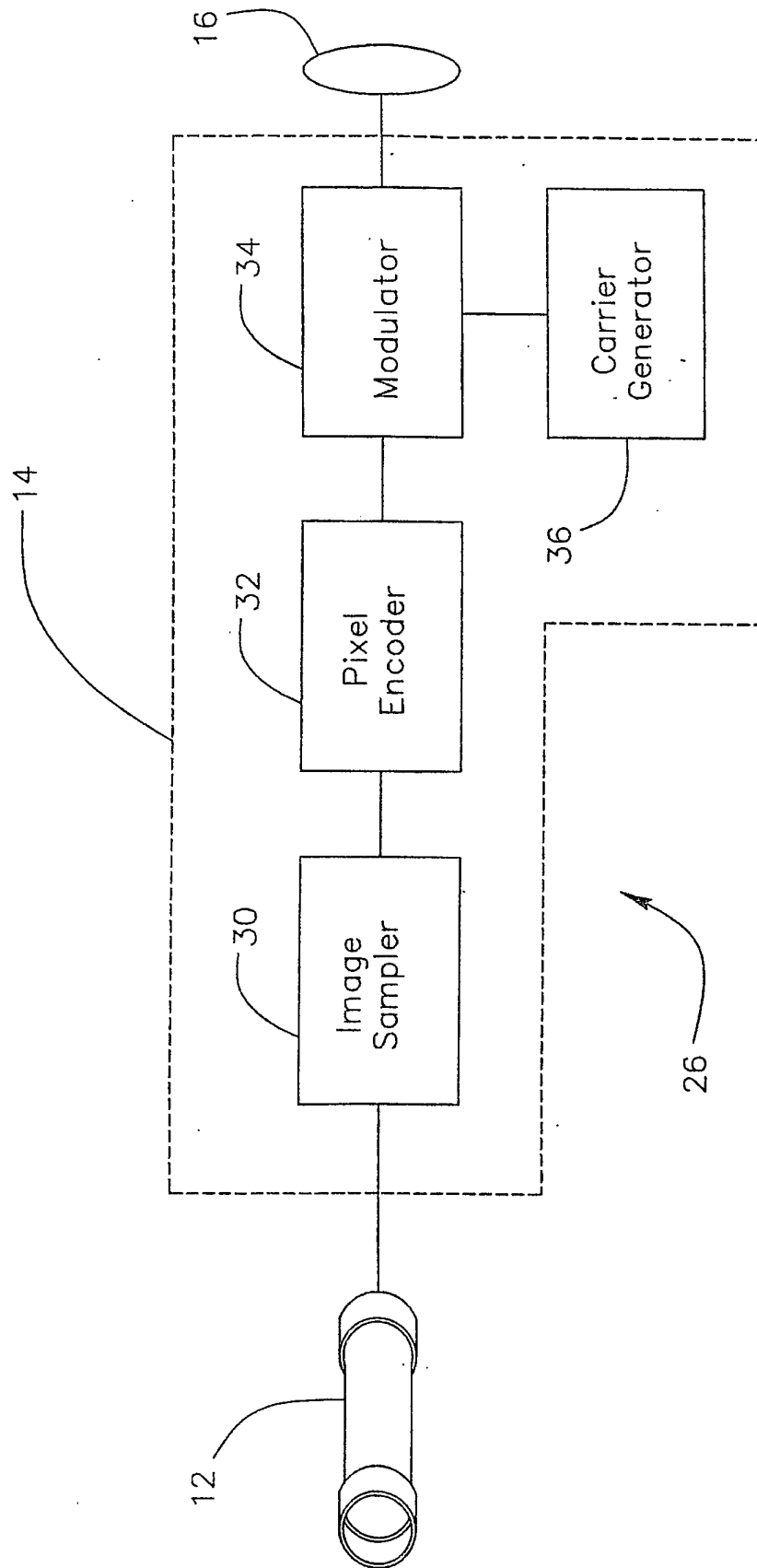


FIG. 2

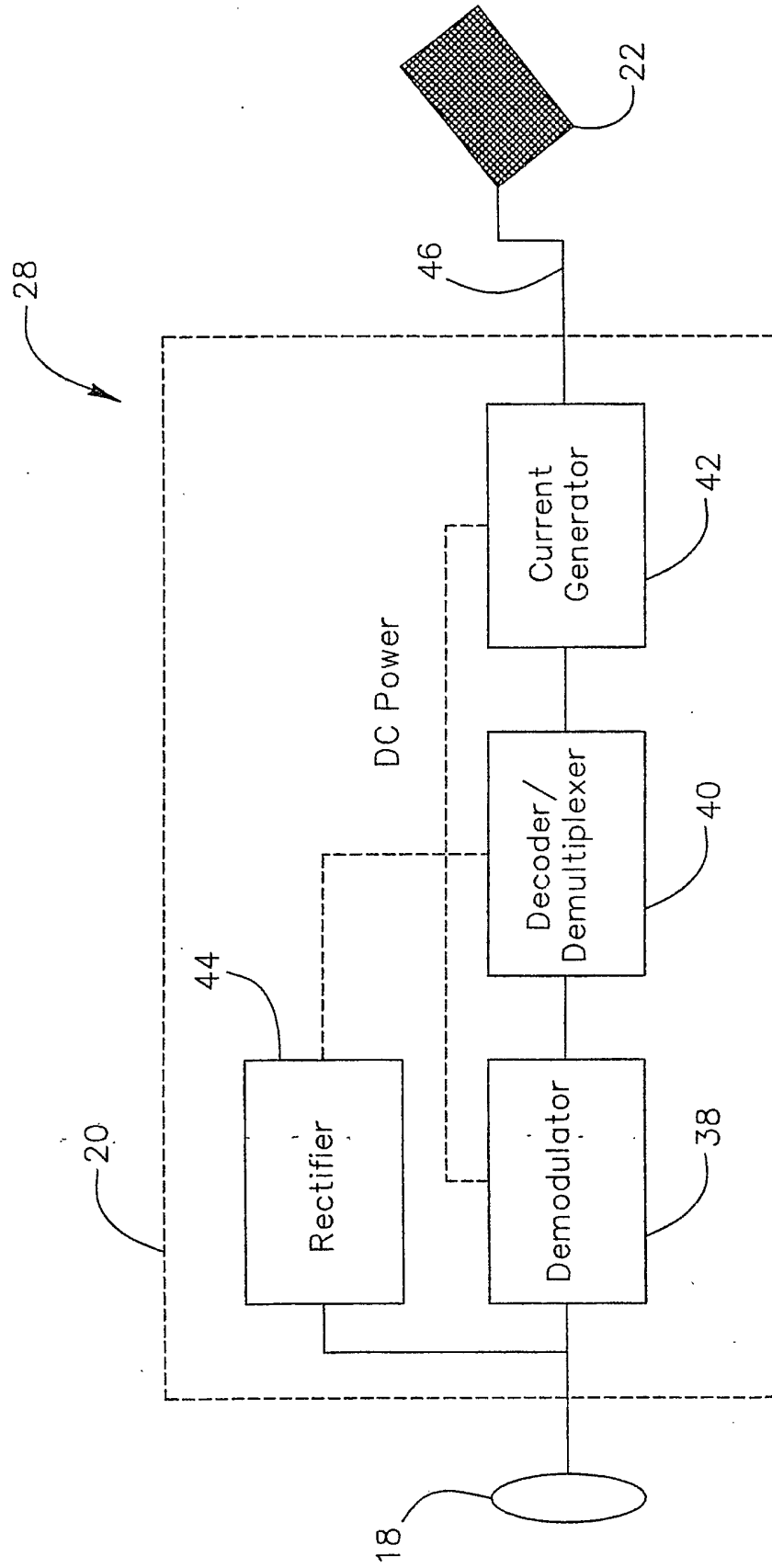
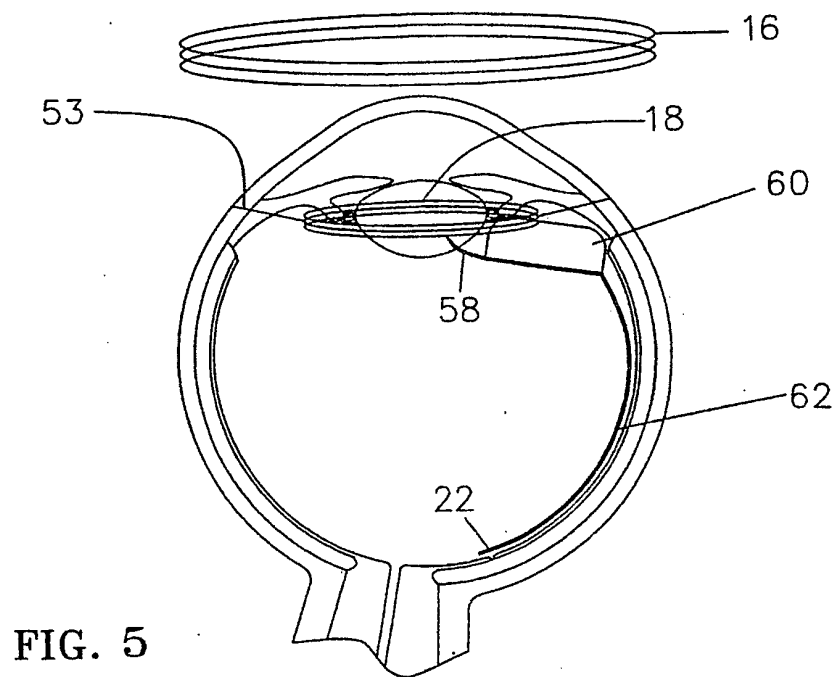
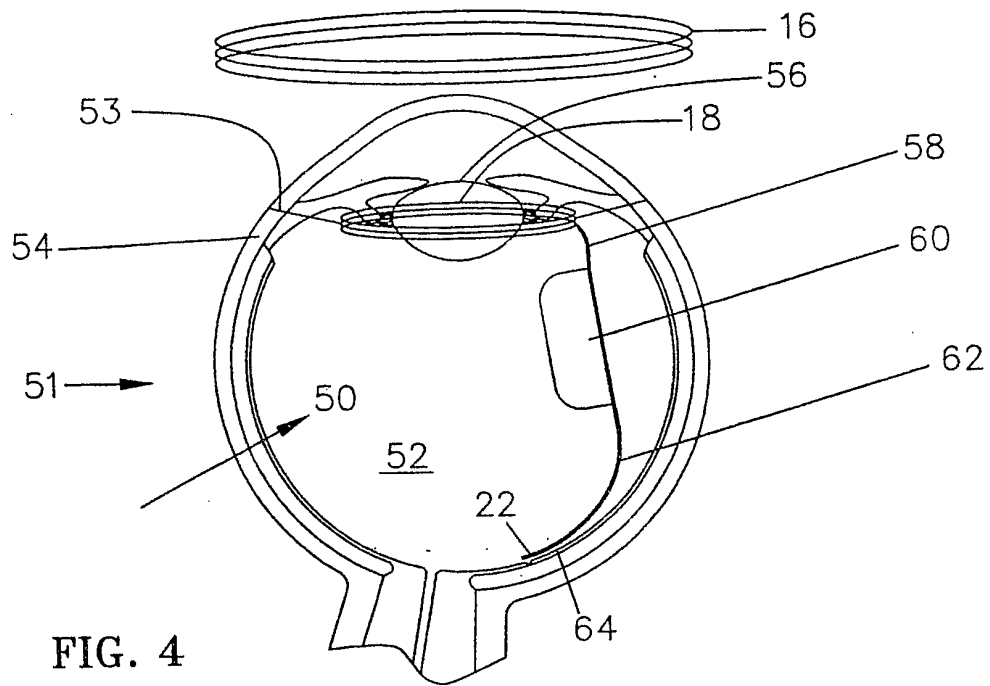
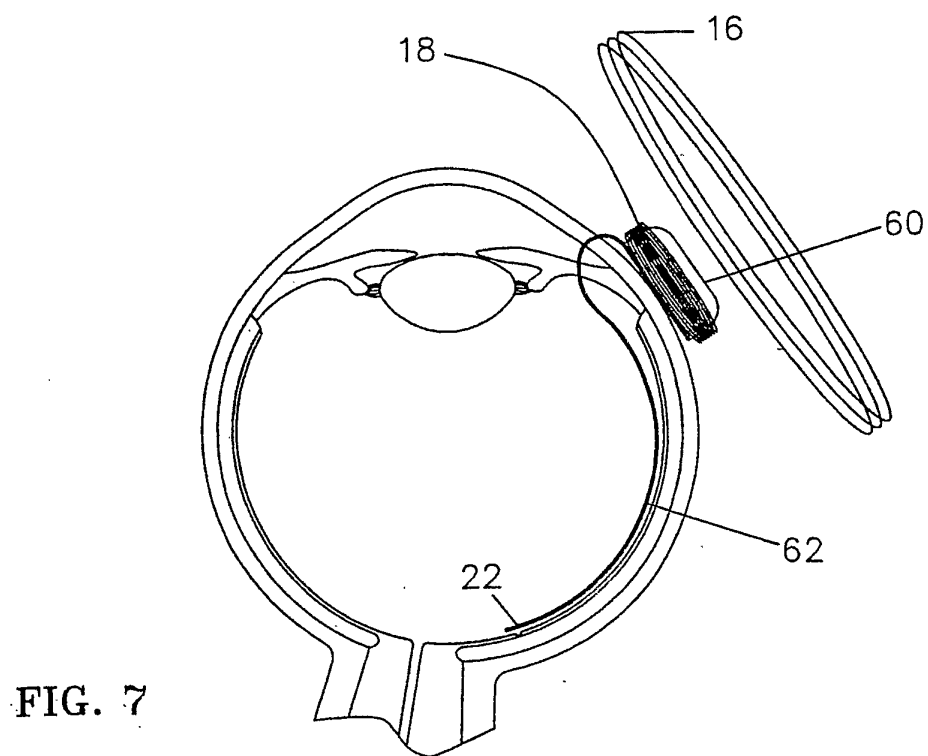
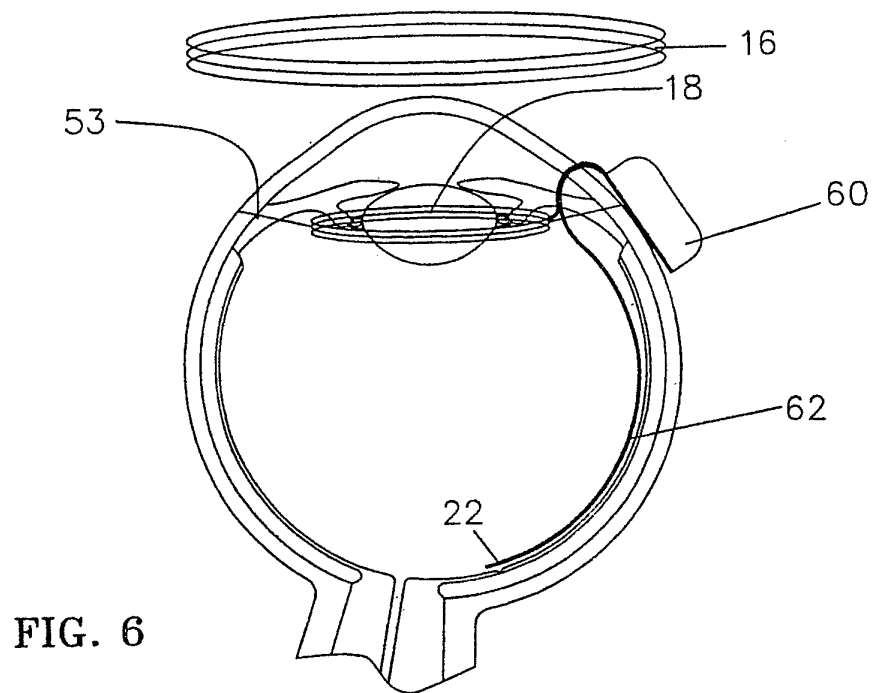


FIG. 3





REFERENCES CITED IN THE DESCRIPTION

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